New Perspectives on Mercury in the Human Environment

Written remarks by

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I am Leonard Levin, technical leader at EPRI, which is a non-profit, collaborative organization conducting energy-related R&D in the public interest. Our members are public and private organizations in the electricity and energy fields, and we now serve more than 1000 energy and governmental organizations in more than 40 countries. These remarks constitute a synthesis of current research on environmental mercury, and are not a representation of official EPRI position.

Introduction

As a global pollutant, the impact of mercury on the human environment is a critical issue that EPRI and the scientific community have been examining for many years. As the scientific understanding of where mercury originates nationally and globally, combined with the new health data, continues to be refined, it can help inform decisions regarding its management. I would like to address three key questions where new findings have emerged. First, where does mercury found in the U.S. environment originate? Second, how much has mercury in fish changed in the last few decades? And third, how do potential mercury management steps change the amount of mercury depositing to the earth's surface in the U.S.?

Where Does Mercury in the U.S. Environment Originate?

Mercury is clearly a global issue. Recent estimates are that, in 1998, some 2340 tons of mercury were emitted globally through industrial activity; of these, more than half, or 1230 tons, came from Asian countries, primarily China[1]. These findings are similar to those of other global inventories[2]. In addition, it is estimated that another 1300 tons of mercury emanates from land-based natural sources globally, including abandoned mining sites and exposed geological formations. Another 1100 tons or so issues from the world's oceans, representing both new mercury emitted by undersea vents and volcanoes, and mercury cycled through the ocean from the atmosphere previously. Recent findings from the large U.S.-Canadian METAALICUS field study in Ontario, Canada showed that a fairly small amount of deposited mercury, no more than 20% or so, re-emits to the atmosphere, even over a two-year period. The implications of this are profound: mercury may be less mobile in the environment than we previously thought; once it is removed from the atmosphere, it may play less of a role in the so-called "grasshopper effect[3]" where persistent global pollutants are believed to successively deposit and re-emit for many years and over thousands of miles.

Recent studies by EPRI have shown that the mercury depositing into the U.S. from the atmosphere may originate at very distant points. Model assessments show that, for 3/4 of the area of the continental United

[1] Christian Seigneur, C., K. Vijayaraghavan, K. Lohman, Pr. Karamchandani, C. Scott, Global Source Attribution for Mercury Deposition in the United States, submitted to Environ. Sci. Technol., 2003
[2] Jozef M. Pacyna, Elisabeth G. Pacyna, Frits Steenhuisen and Simon Wilson, Mapping 1995 global anthropogenic emissions of mercury, Atmospheric Environment 37 (S1) (2003) pp. 109-117
[3] Environment Canada, The Grasshopper Effect and Tracking Hazardous Air Pollutants, The Science and the Environment Bulletin, May/June 1998.

States, more than 60% of the mercury received originates outside U.S. borders, from other countries or even other continents. Only 8% of U.S. territory receives 2/3 or more of its mercury from U.S. domestic sources, and less than 1% of U.S. territory gets 80% or more of its mercury from sources within the U.S. One implication of this dichotomy between mercury sources and the U.S. areas impacted is that there may be a "management floor" for U.S. mercury, a level below which the amount of mercury depositing to the surface cannot be reduced.

Additional evidence for the external origins of much of the mercury in the U.S. environment was gathered over the last 2 years by aircraft experiments carried out by EPRI, the National Center for Atmospheric Research, and a number of U.S., Asian, and Australian investigators. One set of flights measured significant mercury in winds entering the Pacific Ocean from Shanghai, China; researchers tracked the Chinese mercury plume over the Pacific for 400 miles towards America. A second set of flights from Monterey, California, found that same plume from China crossing the California coast, and a second, higher plume of enriched mercury originating in Central Asia also moving into the U.S. The global nature of mercury in the U.S. has been clearly demonstrated.

What are the Primary Sources of Mercury in Fish and the Environment?

For much of the twentieth century, mercury was an essential part of industrial products, such as batteries and switches, or a key ingredient in such other products as house paints. These industrial uses of the element declined significantly in the latter half of the century, and are now less than 10% of their use of fifty years ago[4]. Professor Francois Morel of Princeton University and colleagues recently analyzed newly caught Pacific tuna for mercury[5], and compared those results to the mercury content of similar tuna caught in the 1970s. Despite changes in mercury emissions to the atmosphere in those thirty years[6], and a matching increase in the mercury depositing from the atmosphere to rivers and oceans below, Prof. Morel found that mercury levels in tuna have not changed over that time. One conclusion is that the mercury taken up by such marine fish as tuna is not coming from sources on land, such as utility power plants, but from natural submarine sources of mercury, including deep sea volcanoes and ocean floor vents. The implications are that changes in mercury sources on the continents will not affect the mercury levels found in open ocean foodfish like tuna.

An estimate in 2001 by scientists of the Geological Survey of Canada and others[7] estimated that geological emissions of mercury, as well as emissions from inactive industrial sites on land, are five to seven times as large as had been estimated earlier. Recent measurements in the stratosphere by EPRI researchers show a rapid removal of mercury in the upper atmosphere, allowing for additional sources at the surface while still maintaining the measured rates of deposition and removal needed for a global balance of sources and sinks. As a result, it is now possible to attribute a greater fraction of the mercury entering U.S. waters to background natural sources rather than industrial emissions from the U.S. or elsewhere globally.

How Could Potential Mercury Reductions Change Mercury Deposition?

EPRI recently completed work to assess the consequences of further mercury emissions reductions for mercury in the atmosphere, U.S. waterways, and fish[8]. The approach used linked models of atmospheric mercury chemistry and physics with analyses of federal data on mercury in fish in the U.S. diet, along with a model of costs needed to attain a given reduction level.

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[4] Engstrom, D.R., E.B. Swain, Recent Declines in Atmospheric Mercury Deposition in the Upper Midwest, Environ. Sci. Technol.1997, 31, 960-967

[5] Kraepiel, A.M.L., K. Keller, H.B. Chin, E.G. Malcolm, F.M.M. Morel, Sources and Variations of Mercury in Tuna, Meeting of American Society for Limnology and Oceanography, Salt Lake City, Utah: January 2003

[6] Slemr, F., E-G. Brunke, R. Ebinghaus, C. Temme, J. Munthe, I. Wangberg, W. Schroeder, A. Stgeffen, T. Berg, Worldwide trend of atmospheric mercury since 1977, Geophys. Res. Ltrs., 30 (10), 23-1 to 23-4

[7] Richardson G. M., R. Garrett, I. Mitchell, M. Mah-Paulson, T. Hackbarth, Critical Review On Natural Global And Regional Emissions Of Six Trace Metals To The Atmosphere, International Lead Zinc Research Organization, International Copper Association, Nickel Producers Environmental Research Association

[8] EPRI Technical Report 1005224, "A Framework for Assessing the Cost-Effectiveness of Electric Power Sector Mercury Control Policies," EPRI, Palo Alto, CA, May 2003.

Current U.S. utility emissions of mercury are about 46 tons per year. At the same time, a total of about 179 tons of mercury deposit each year in the U.S., from all sources global and domestic. One proposed management scenario examined cutting these utility emissions by 47%, to 24 tons per year. The analysis showed that this cut results in an average 3% drop in mercury deposition into the U.S. Some isolated areas totaling about 1% of U.S. land area experience drops of up to 30% in mercury deposited. The cost model used in association with these calculations showed utility costs to reach these emission control levels would amount to between $2 billion and $5 billion per year over 12 years. This demonstrated that U.S. mercury patterns are relatively insensitive to the effects of this single category of sources.

In addition, most of the fish consumed in the U.S. comes from ocean sources, which would be only marginally affected by a global reduction of 24 tons of mercury per year due solely to U.S. controls. Wild fresh water fish in the U.S. would be expected to show a greater reduction in mercury content, but are a relatively small part of the U.S. diet compared to ocean or farmed fish. When these changes were translated into how much less mercury enters the U.S. diet, we found that 0.064% fewer children would be born "at risk" due to their mothers taking in less mercury from consumed fish. These results were based on the federal dietary fish consumption data. So, a drop of nearly half in utility mercury emissions results in a drop of 3% (on average) in mercury depositing to the ground, and a drop of less than one-tenth of a percent in the number of children "at risk."

Decisionmaking Under Uncertainty

These recent findings on mercury sources, dynamics, and management are a small part of the massive international research effort to understand mercury and its impacts on the human environment. EPRI and others, including the U.S. Environmental Protection Agency and the U.S. Department of Energy, are racing to clarify the complex interactions of mercury with geochemical and biological systems, vital to understanding mercury's route to human exposure and potential health effects. With this improved understanding, informed decisions can be made on the best ways to manage mercury.

Thank you for the opportunity to deliver these remarks to the Committee.